SIGNIFICANCE OF THE INTERCONNECTIVITY OF INTERMETALLIC LAVES PHASES ON THE MECHANICAL BEHAVIOR OF MG-AL-CA ALLOYS

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Key Words: Mg-Al-Ca alloys, Thermal activation, Mechanical behavior, Nanoindentation, μ-DIC.

As-cast Mg-Al-Ca alloys are among the most promising alloys for elevated temperature automotive applications (≤ 200 °C) due to their superior creep properties as compared to conventional AZ or AM series Mg alloys. The microstructure of Mg-Al-Ca alloys consist of an α-Mg matrix reinforced with hard interconnected intermetallic (IM) Laves phases. These IM Laves phases are the main reason for the better creep resistance of these alloys. In this study we show that the type, morphology and distribution of IM Laves phases and consequently also the mechanical properties can be manipulated by varying the Ca/Al ratio. An increase in Ca/Al ratio from 0.3 to 1.0 results in i) higher volume fraction of IM Laves phases in the microstructure, ii) improvement in the yield strength (YS), and iii) enhancement in creep resistance at a stress level of 50-70 MPa and a temperature of 170 °C of the as-cast alloys.

Further, we investigate the deformation behavior of an Mg-3.7Al-3.8Ca alloy (Ca/Al ratio of 1.0) within a temperature range of 20-200 °C using three different nanoindentation techniques: constant strain rate tests, strain rate jump tests and creep tests all in conjunction with scanning electron microscopy (SEM) and atomic force microscopy (AFM). The hardness obtained for the α-Mg phase at all testing temperatures was lower than the hardness measured across α-Mg/Laves phase interfaces, presumably due to the higher intrinsic hardness of the Laves phases. The strain rate sensitivity, *m*, of the α-Mg phase increases with temperature, with values of 0.014 measured at 100 °C and 0.025 at 170 °C, respectively. The indents made across α-Mg/Laves phase interfaces exhibited *m* values close to and in some cases even higher than the *m* values of the α-Mg phase indicating significant thermal activation in the interfacial regions. The nanoindentation creep tests showed that the creep properties of the Mg_2Ca Laves phase are intrinsically better than that of the α-Mg phase. However, creep tests on regions with a high fraction of interfaces revealed deformation by interfacial sliding resulting in similar creep properties as the α-Mg phase. Parallel slip lines along specific equivalent crystallographic planes were clearly visible on the surface of the Laves phase in and around the indents.

Moreover, the local strain distribution and partitioning at the microstructural level occurring during high temperature tensile deformation (at ≈170 °C) was measured using quasi in-situ DIC in SEM revealing i) strain localisation at the α-Mg/Laves phase interfaces suggesting deformation by interfacial sliding, ii) strain concentration along basal slip lines and tensile twinned regions in the α-Mg matrix, and iii) fracture of Laves phases in regions of strain concentration.